



NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

April 14, 2004

Fire Fighter-Paramedic Suffers Sudden Cardiac Death While Performing Physical Fitness Training – Washington

SUMMARY

On November 17, 2003, a 35-year-old male career Fire Fighter-Paramedic (FF-P) had just completed a two-mile run on the fire station's treadmill when he suddenly collapsed. The collapse was witnessed by a crew member (Lieutenant) who called Dispatch for assistance. Approximately 30 seconds later, the FF-P had stopped breathing and became pulseless. The crew member retrieved the station's automated external defibrillator (AED) and defibrillated the FF-P while beginning cardiopulmonary resuscitation (CPR). Other advanced life support (ALS) began to arrive at the fire station and resuscitation efforts continued for an additional 22 minutes. Unfortunately, there was no change in his status, and the FF-P was pronounced dead at the scene by the Medical Examiner. The death certificate and autopsy, completed and performed by the Medical Examiner, listed "occlusive atherosclerotic cardiovascular disease" as the immediate cause of death.

The following recommendations address some general health and safety issues. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These selected recommendations have not been evaluated by NIOSH, but represent published research, or consensus votes of technical committees of the National Fire Protection Association (NFPA) or fire service labor/management groups.

Although unrelated to this fatality, the Fire Department should consider these recommendations based on health and economic considerations:

- *Provide pre-placement medical evaluations to ALL fire fighters consistent with NFPA 1582 to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others*
- *Provide mandatory annual medical evaluations to ALL fire fighters consistent with NFPA 1582 to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others*
- *Perform a pre-placement and an annual physical performance (physical ability) evaluation for ALL fire fighters to ensure they are physically capable of performing the essential job tasks of structural fire fighting*
- *Provide adequate fire fighter staffing to ensure safe operating conditions*

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at www.cdc.gov/niosh/firehome.html or call toll free 1-800-35-NIOSH



Fatality Assessment and Control Evaluation Investigative Report #F2004-06

Fire Fighter-Paramedic Suffers Sudden Cardiac Death While Performing Physical Fitness Training - Washington

INTRODUCTION & METHODS

On November 17, 2003, a 35-year-old male Fire Fighter-Paramedic had just finished running on the treadmill when he suddenly collapsed. Despite ALS treatment at the scene, the FF-P died. NIOSH was notified of this fatality on November 19, 2003, by the United States Fire Administration. NIOSH contacted the affected Fire Department on November 25, 2003, to obtain further information. On February 9, 2004, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Washington to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel met and/or interviewed:

- The Fire Chief
- The EMS Division Chief
- The Training Division Chief
- The FF-P's crew members
- The FF-P's wife
- The wellness clinic

During the site-visit NIOSH personnel reviewed:

- Fire Department policies and operating guidelines
- Fire Department training records
- The Fire Department annual report for 2003
- Fire Department incident report
- Fire Department physical examination protocols
- Ambulance records
- Death certificate
- Autopsy report

INVESTIGATIVE RESULTS

On November 17, 2003, the FF-P reported for duty at his fire station (Station 12-4) at 0700 hours. He was on duty with one crew member, his Lieutenant (LT). Throughout the morning, the crew checked the apparatus (pumper and water tender), performed normal house duties, and attempted to check hydrant

flows in a new housing development. The crew returned to the station and ate lunch. During the afternoon, the crew performed an apparatus operator drill in which the FF-P operated the pumper. After the drill was completed, the FF-P hung a file holder and a grease board in the office. At approximately 1630 hours, the FF-P began his physical fitness training.

The FF-P ran on the treadmill for 30 minutes, running approximately two miles. During this time he complained of indigestion, but he continued his workout. After he completed 30 minutes, the FF-P sat down to stretch his muscles. Suddenly the FF-P laid down and appeared to be snoring and having a seizure (body stiffened). The crew member witnessing this incident checked the FF-P's vital signs and found him to be unresponsive, breathing, with a pulse, but stiff. The crew member immediately called 911 for a seizure (1712 hours) and Ambulance 1607 was dispatched. The crew member saw the FF-P relax, and upon checking the FF-P, found him to be unresponsive, pulseless, and not breathing. The crew member retrieved an automated external defibrillator (AED) and oxygen equipment and began CPR (chest compressions and mouth-to-mask respirations). The FF-P regurgitated and the crew member suctioned his airway. An oral airway was inserted into the FF-P's trachea to keep the airway open. The Fire Chief arrived at the scene at approximately 1715 hours and assisted. At 1716 hours, the crew member called Dispatch to alert them of the change in patient status.

Attached to the FF-P, the AED advised "Shock Advised" and one shock (defibrillation) was delivered at 1719 hours with no change in patient status. The AED "analyzed the patient" and no shock was advised. CPR was continued and oxygen (100%) was administered via bag-valve-mask (BVM). The City Police Chief arrived and provided assistance with CPR.

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The Ambulance arrived at the scene at 1724 hours (12 minutes post collapse) and re-evaluation by the ambulance staff found the FF-P to be unresponsive, pulseless, and not breathing. A cardiac monitor attached to the FF-P revealed asystole (no heart beat) at 1731 hours. The FF-P was intubated and tube placement was confirmed by auscultation (bilateral breath sounds) and with a capnometer (measures exhalation for carbon dioxide). An intravenous (IV) line was placed and cardiac resuscitation medications were administered with no change in patient status. After 22 minutes of ALS resuscitation efforts (total of 33 minutes), his heart condition did not improve (he remained in asystole). Per County ALS protocols¹ the emergency department physician was contacted, patient information discussed, and the physician advised to cease resuscitation efforts. The coroner was notified, arrived at the scene, and the FF-P was pronounced dead at 1745 hours.

Medical Findings. The death certificate, completed by the Medical Examiner, listed “occlusive atherosclerotic cardiovascular disease” as the immediate cause of death. Pertinent findings from the autopsy, performed by the Medical Examiner on November 18, 2003, included:

- Heart weighing 400 grams
- Atherosclerotic cardiovascular disease
 - 100% occlusion in the right coronary artery with a right dominant coronary artery system
 - 75% stenosis in the circumflex artery
 - 75% stenosis in the left anterior descending artery
- 0.7 centimeter area of increased consistency which is slightly grayer than adjacent areas in the posterior lateral aspect of the left ventricular wall in the apical third
- No thrombi or emboli
- No fibrosis
- Drug and alcohol tests were negative

On autopsy, the deceased weighed 175 pounds and was 68 inches tall, giving him a body mass index (BMI) of 27 kilograms per square meter (kg/m²). (A BMI between 25 and 29.9 kg/m² is considered overweight).² According to the FF-P’s wife and Fire Department personnel, the FF-P walked and ran regularly. At his pre-placement physical examination in April 2003, the FF-P weighed 169 pounds, had a blood pressure of 122/78 millimeters of mercury (mmHg), cholesterol level was 233 milligrams per deciliter (mg/dL) (normal 150-200 mg/dL), LDL level was 174 mg/dL (normal 68-100 mg/dL), HDL 38.9 mg/dL (normal > 40 mg/dL), cholesterol/HDL ratio was 5.99 (normal < 5.0), and his LDL/HDL ratio was 4.47 (normal 0-4.22). The FF-P was diagnosed with hypercholesterolemia, notified of the results, and advised to continue exercise and eat a low fat, low cholesterol diet. He exercised for 21 minutes, 30 seconds on the Balke Treadmill Test³, achieving 13 metabolic equivalents (METs) and 102% of his predicted maximum heart rate. His blood pressure response was normal.

During the shift three days prior to his collapse, the FF-P suffered a hip injury while testing a fire hydrant. Later during the shift while running on the treadmill, he complained of indigestion, stopped after approximately 15 minutes, and could not continue. However, after he sat down a short time, the indigestion subsided. He only complained of hip pain over the weekend prior to his death. The FF-P had participated in the Atkins diet for approximately 8 months and had lost approximately 54 pounds, although in the last month he was not following the Atkins diet plan. He was not prescribed any medications.

**DESCRIPTION OF THE FIRE
DEPARTMENT**

At the time of the NIOSH investigation, this combination Fire Department consisted of 45



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uniformed personnel (9 career and 36 volunteer). The Department served a population of 12,500 in an area of 65 square miles. There are 4 fire stations (3 staffed and 1 volunteer). The FD also provides ALS medical service; however patient transport is provided by a private ambulance company. Fire fighters work the following schedule: 24 hours on-duty, 48 hours off-duty, 0700 hours to 0700 hours.

In 2003, the Department responded to 1,118 calls, including: 808 medical calls and 310 fire-related calls.

Training. The Fire Department requires all new career fire fighter applicants to be a State-licensed paramedic, pass a basic aptitude test, pass a modified Cooper physical assessment and a physical agility test, pass a situational assessment, pass a psychological exam, and a Chiefs' interview prior to being hired contingent on passing a drug screen and a pre-placement physical examination performed by a County-contracted clinic. The newly hired fire fighter candidate then receives a two-week orientation and is sent to the 10-week State Fire Training Academy to become certified as Fire Fighter I and Hazardous Materials Operations level. The new fire fighter then completes another 10-week orientation based on company operations and is then assigned a shift. During the probationary first year, the fire fighter begins apparatus operator training.

The Fire Department requires all new volunteer fire fighter applicants to complete an application, pass a multi-state criminal background check, pass a physical agility test, a written test, physical examination, and an oral examination prior to being selected. Once selected, the new volunteer is sent to a joint training facility for the 6-week Basic Fire Fighter Academy. Once the volunteer has completed this training, the fire fighter is assigned a station and shift (must complete 24-hours monthly) and must complete a task book based on company operations.

The physical agility test (a two-part test used to assess general physical fitness and the ability to perform job functions) consists of the following:

- General Physical Fitness
 - Complete 30 bent-knee situps in 60 seconds
 - Complete 25 push-ups
 - Complete a 2-mile run in 17 minutes
- Job Function Ability
 - Lift a 16-foot roof ladder from the ground, properly place it on an engine ladder rack, then return the ladder to the ground
 - Equipment carry
 - Lift a circular saw and a chain saw (one in each hand), carry them for 200 feet, and place them on the ground
 - Climb a 75-foot aerial ladder placed at a 60-degree angle while wearing gloves, coat, helmet, and an SCBA without mask
 - Negotiate through a padded narrow maze approximately three feet in diameter on hands and knees while wearing blacked-out SCBA mask, structural firefighting coat, gloves, helmet, and SCBA

Recurrent training occurs daily on each shift. State fire fighter certification is voluntary. There is no mandatory annual refresher training. EMTs and Paramedics recertify every three years. The FF-P was certified as a Fire Fighter I, EMT-Paramedic, and in Hazardous Materials Operations. He had 6 months of fire fighting experience and 12 years experience as a paramedic.

Pre-placement Evaluations. The FD requires a pre-placement medical evaluation for career fire fighter candidates only, regardless of age. Components of the evaluation include:

- A complete medical history
- Physical examination
- Vital signs
- Vision screening
- Audiogram

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- Blood analysis: lipid panel complete blood count
- Urine dipstick
- Drug screen
- Chest x-ray
- 12-lead resting electrocardiogram (EKG)
- Hepatitis screening (Hepatitis B)
- Pulmonary Function Test (spirometry)
- Exercise Treadmill Test (Balke protocol)³

These evaluations are performed by a contract physician hired by the County, who then makes a decision regarding medical clearance for fire fighting duties. This decision is forwarded to the Fire Chief.

Periodic Evaluations. Periodic medical evaluations are not offered by this Department. Annual physical ability testing is not required. Medical clearance for respirator use is required annually.

If an employee is injured at work, or is ill and off work (depending on the injury or illness), the employee may have to be evaluated by the Fire Department-contracted physician, who forwards their recommendation regarding “return to work” to the Fire Chief, who makes the final determination.

Exercise (strength and aerobic) equipment is located in all fire stations. The FD is in the process of purchasing additional exercise equipment for all its fire stations. Mandatory wellness/fitness programs are in place for the Department. Health/wellness maintenance information is available from the County.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.⁴ Risk factors for its development include age over 45, male gender, family history of coronary artery disease, smoking, high blood pressure (systolic >140 millimeters of mercury [mmHg] or diastolic > 90

mmHg), high blood cholesterol (total cholesterol > 240 milligrams per deciliter [mg/dL]), obesity/physical inactivity, and diabetes.^{5,6} The victim had two of these risk factors (male gender and high blood cholesterol). He had participated in the Atkins diet for 8 months and had lost approximately 54 pounds. There are differing viewpoints on any possible links between the high-fat, low carbohydrate Atkins diet and cardiovascular disease.⁷⁻¹⁰

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.¹¹ However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.¹² Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.¹³ This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. The deceased did not have a blood clot on autopsy but he did have evidence of atherosclerotic disease in his coronary arteries with 100% narrowing of the right coronary artery, and 75% narrowing of the left anterior descending coronary artery and the circumflex coronary artery.

Atherosclerosis in a coronary artery may cause ischemic heart disease which occurs when the blood flow within a coronary artery, probably the right coronary artery in this case, is limited to the point where the oxygen needs of the heart muscle cannot be met. Chronic ischemic heart disease causes hypertrophy of the heart muscle and cardiomegaly. All of these factors, independently and in combination (ischemia, cardiomegaly, or myocardial infarction), increase the risk of cardiac arrhythmia and sudden cardiac death.

It is also possible/probable that the FF-P suffered a heart attack. The term “probable” is used because autopsy findings (thrombus formation), blood tests

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(cardiac isoenzymes), or ECG findings are required to “confirm” a heart attack [myocardial infarction (MI)]. The victim did not have a coronary artery thrombus on autopsy; he died prior to the cardiac isoenzymes becoming positive, and he had no heart beat to show the characteristic findings of a heart attack on his ECG.

Angina is the most common presenting symptom of myocardial ischemia and underlying CAD, but in many persons the first evidence of CAD may be myocardial infarction or sudden death.¹⁴ Some individuals may not experience angina with ischemia, as evidenced by up to 20% of heart attacks being “silent,” i.e., painless.¹¹ On the other hand, sometimes atypical symptoms (indigestion, left arm pain, jaw pain, etc.) can be an expression of angina. The FF-P’s indigestion may have been an atypical presentation of angina. He did not report any episodes of chest pain during physical activity (only indigestion), while performing duties as a fire fighter, or off-the-job.

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.¹⁵ Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.¹⁶⁻¹⁸ Even when energy costs are moderate (as measured by oxygen consumption) and work is performed in a thermoneutral environment, heart rates may be high (over 170 beats per minute) owing to the insulative properties of the personal protective clothing.¹⁹ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.²⁰⁻²³ The deceased ran for approximately two miles within a 30-minute timeframe on the treadmill. This is considered a very heavy level of physical exertion.^{24,25} The physical

stress of exercising and his underlying atherosclerotic CAD contributed to this fire fighter’s cardiac arrest and sudden death.

RECOMMENDATIONS

The following recommendations address health and safety generally. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These recommendations have not been evaluated by NIOSH, but represent published research, or consensus votes of technical committees of the NFPA or fire service labor/management groups.

Although unrelated to this fatality, the Fire Department should consider these recommendations based on health and economic considerations:

Recommendation #1: Provide pre-placement medical evaluations to ALL fire fighters consistent with NFPA 1582 to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Guidance regarding the content and frequency of periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments,²⁶ and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.²⁷ The Department is not legally required to follow any of these standards.

The success of medical programs hinges on protecting the affected fire fighter. The Department must **1)** keep the medical records confidential, **2)** provide alternate duty positions for fire fighters in rehabilitation programs, and **3)** if the fire fighter is not medically

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qualified to return to active fire fighting duties, provide permanent alternate duty positions or other supportive and/or compensated alternatives.

Recommendation #2: Provide mandatory annual medical evaluations to ALL fire fighters consistent with NFPA 1582 to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others

Guidance regarding the content and frequency of periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments,²⁶ and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.²⁷ The Department is not legally required to follow any of these standards.

The success of medical programs hinges on protecting the affected fire fighter. The Department must **1)** keep the medical records confidential, **2)** provide alternate duty positions for fire fighters in rehabilitation programs, and **3)** if the fire fighter is not medically qualified to return to active fire fighting duties, provide permanent alternate duty positions or other supportive and/or compensated alternatives.

Recommendation #3: Perform a pre-placement and an annual physical performance (physical ability) evaluation for ALL fire fighters to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting

NFPA 1500 requires fire department members who engage in emergency operations to be annually evaluated and certified by the fire department as meeting the physical performance requirements identified in paragraph 8-2.1.²⁸

Recommendation #4: Provide adequate fire fighter staffing to ensure safe operating conditions.

Currently, the FD staffs its engines with two-three personnel and its ladders with two-three personnel. NFPA 1710 requires that “on-duty personnel assigned to fire suppression shall be organized into company units and shall have appropriate apparatus and equipment assigned to such companies.”²⁹ Those companies may respond with two apparatus, depending on the seating configuration of the apparatus to ensure four personnel arrive on scene.²⁹ Personnel assigned to the initial arriving company shall have the capability to implement an initial rapid intervention crew (IRIC),²⁹ which requires four personnel (two to enter the structure and two standing by outside). NFPA 1500 recommends that “members operating in hazardous areas at emergency incidents shall operate in teams of two or more.”²⁸ Understaffing causes those members on-scene to work harder and for longer periods of time. Additionally, it requires the use of extra fire companies in order to meet the demand for manpower. Engine and Ladder Companies should be staffed with four personnel at a minimum.

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INVESTIGATOR INFORMATION

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